Shoreline Remediation of Petroleum Hydrocarbons Using an Oleophilic Bio Barrier for Sheen Control

Battelle Conference

Jeff Gentry, P.E. Jacobs
Scott Martin, P.G. Kinder Morgan
Keith Sheets, Jacobs
Dr. Tom Sale, Colorado State University
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Agenda

1. Introduction – Site Overview
2. Shoreline Barrier Wall
3. NAPL Site Conceptual Model
4. Oleophilic Bio Barrier Technology
5. Implementation and Results

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Portland Harbor Superfund Site

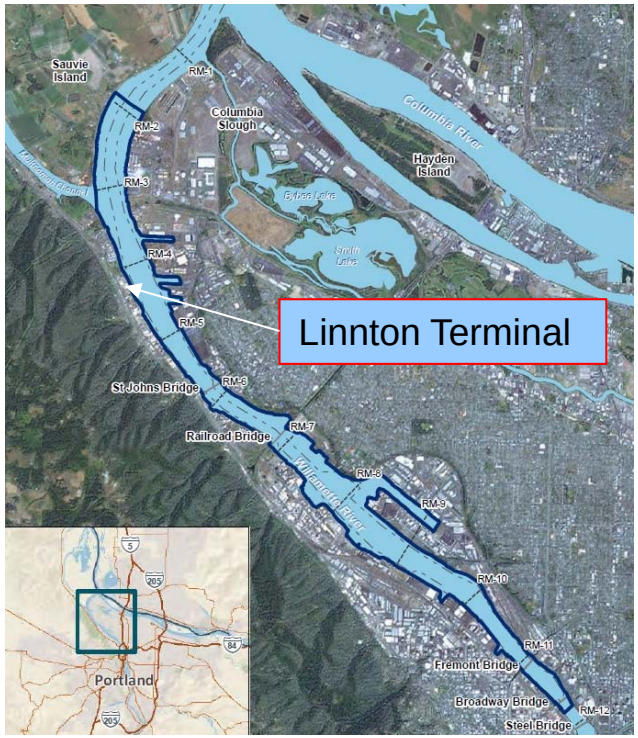

Image from EPA ROD, Figure 1, January 2018

- Located in Portland, Oregon, USA
- Approximately 9 miles of the Willamette River (RM 2 to 11)
- Kinder Morgan Linnton Bulk Terminal Facility at ~RM 4
- Record of Decision issued in January 2018
- Requires the remediation of over 10,000 feet of river bank

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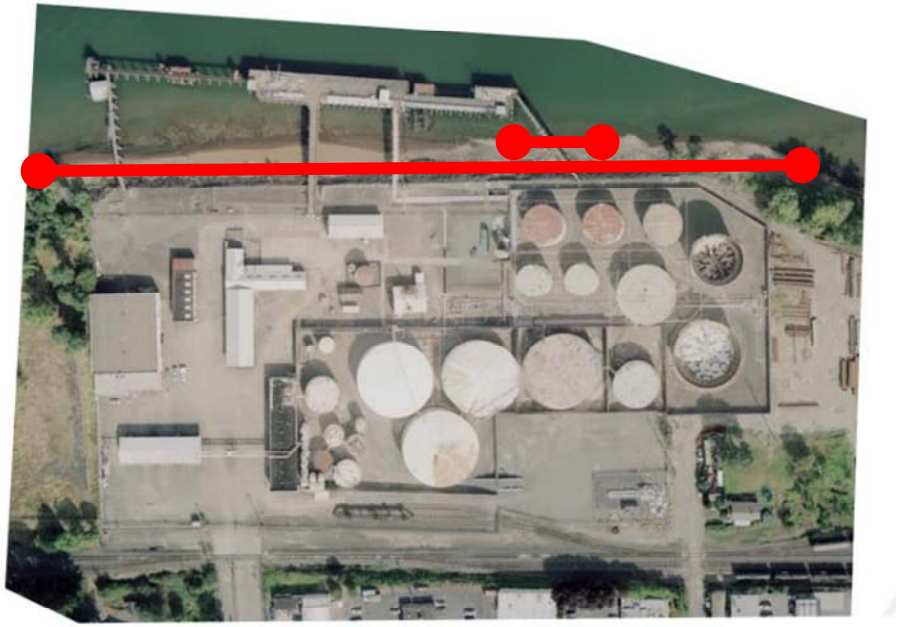
Linnton Terminal Bank



- 1,052 feet of river bank
- 100 feet of river bank has intermittent sheen discharge

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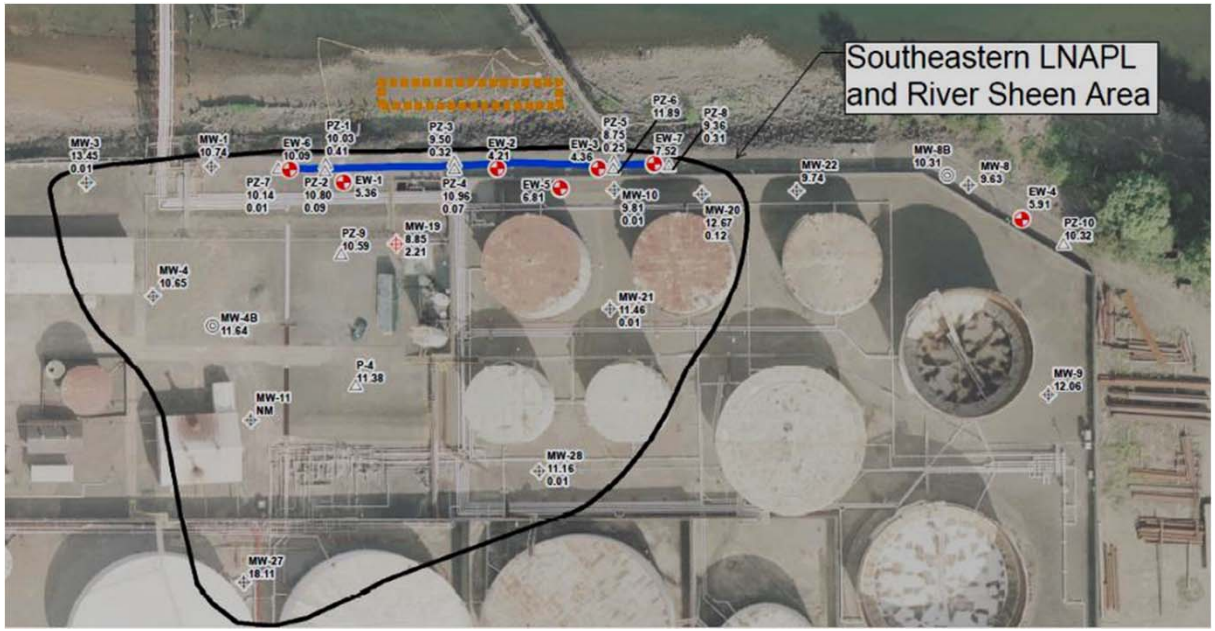
Upland LNAPL Impact Area



- Upland area NAPL impacts from historic releases
- NAPL generally at or below residual levels
- Area decreasing in size due to natural processes
- Bank sheen area shown in gold

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Bank pictures in sheen area

Low Water

High Water

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Linnton Terminal Bank

- Barrier wall installed to block NAPL flow path to the river
- Fiberglass sheet piles with Viton seals
- Bottom penetrated silt underlying silt layer
- Sheets not meeting target depth were grouted to the silt layer

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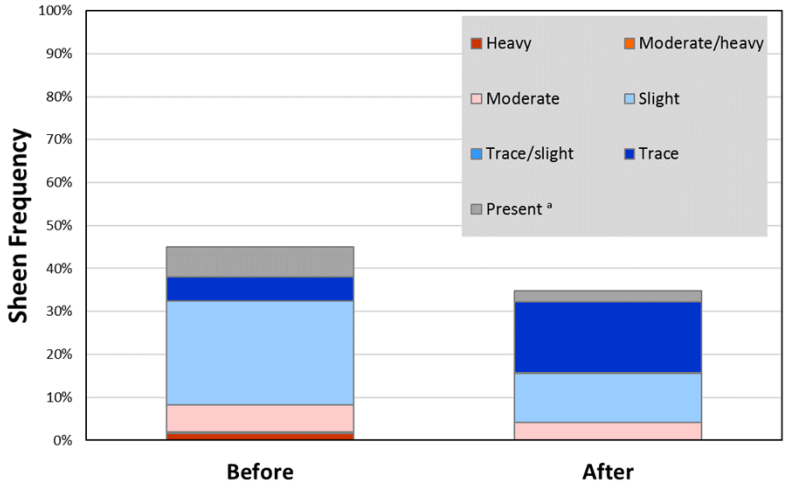
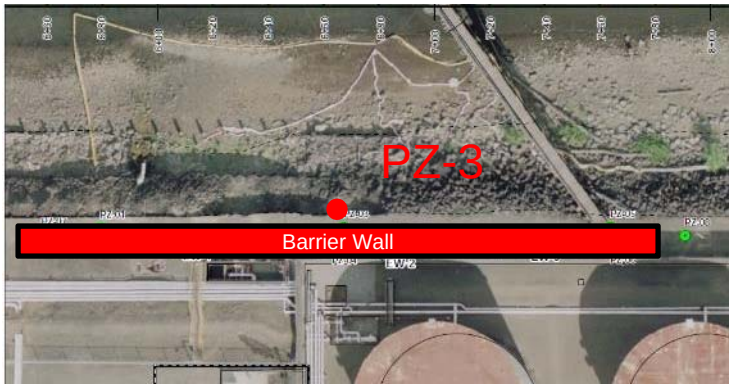
Observations Since Barrier Wall Installation

- Sheens decreasing, but still persists at certain river stages



  - Heavy sheens no longer observed, trace sheens still present

- LNAPL accumulations downgradient of barrier wall



  - Downgradient piezometer have LNAPL accumulations, what does that data tell us

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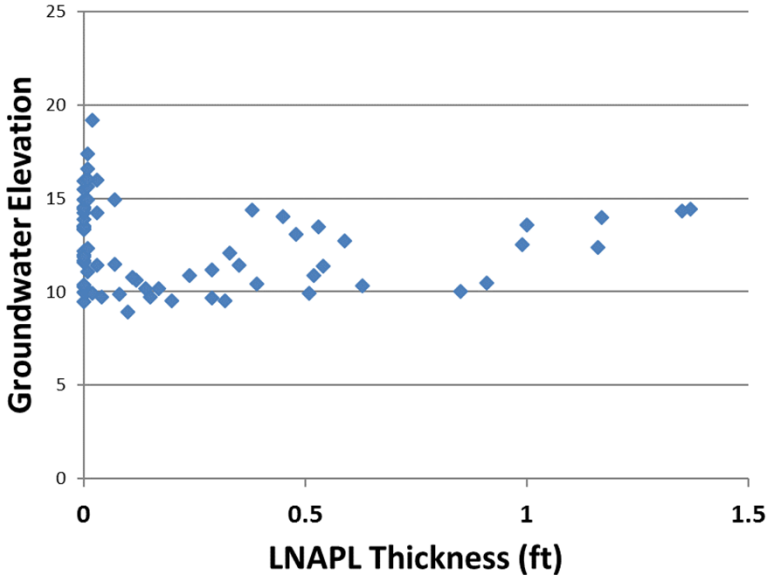
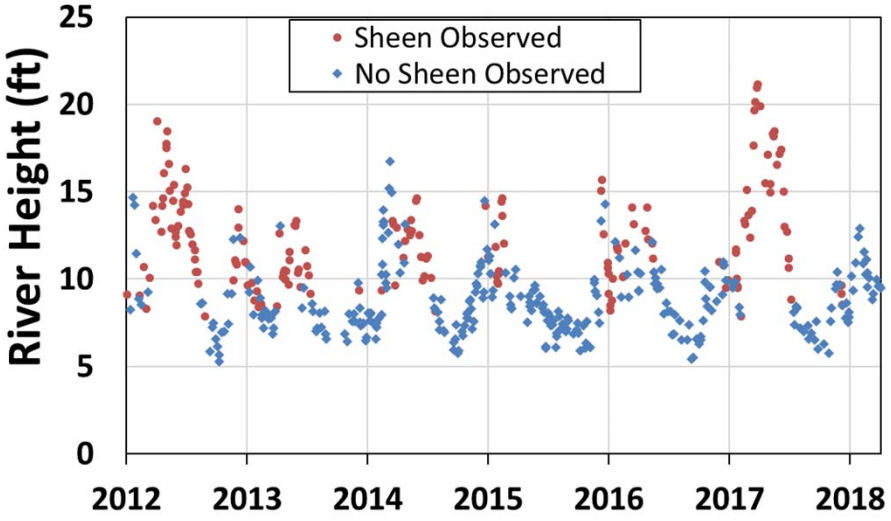
LNAPL Levels and River Observations

Diagnostic gauge plot



Sheen observations



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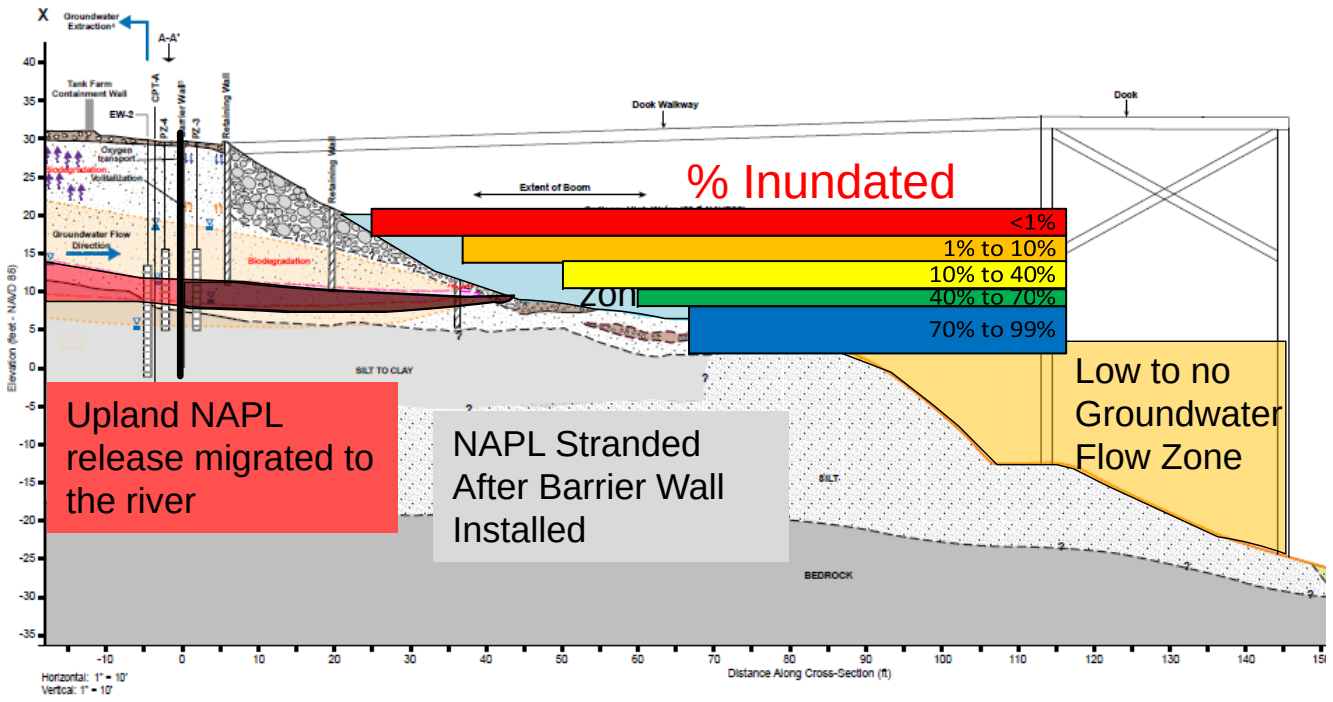
Conceptual Site Model - NAPL



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Adapting to Changing Regulatory Approach

- Prior to Record of Decision
  - Upland source control evaluation under Oregon DEQ oversight
  - Interim measure barrier wall installed in 2011
  - Address intermittent sheen caused by wedge of impacted soil riverward of barrier wall
  - Planned measure to address sheen only and keep out of river
- After ROD
  - Site identified for riverbank remedial action in ROD
  - Riverbank remedial technologies identified in ROD for NAPL impacts
    - Excavation
    - Significantly Augmented Cap
  - Both sheen and pore water impacts need to be addressed
  - DEQ still lead agency, but EPA review required

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Cap Design – NAPL

Cap design will include organoclay, … as necessary,……..

- ROD prescribed organoclay caps for NAPL control
- CSU Research demonstrated organoclay barriers could experience early breakthrough at water table
  - Organoclay lowers water table and creates a trough where LNAPL can accumulate
  - LNAPL can imbibe across the air water interface

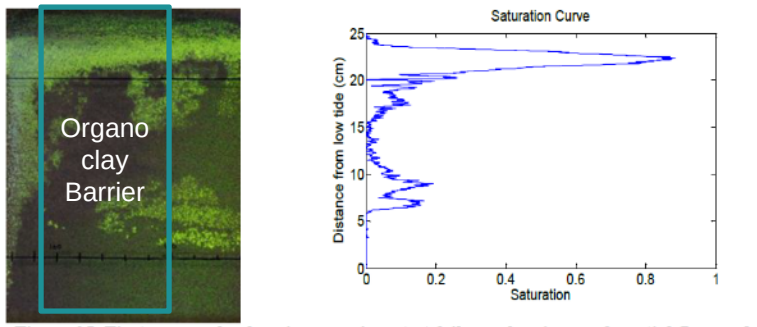

Figure 25. First organoclay barrier experiment at failure, showing preferential flow and the corresponding saturation curve obtained from transformation of the digital image to LNAPL saturation.

Image from Hawkins 2013

Hawkins, Alison M. 2013. "Processes Controlling the Behavior of LNAPLs at Groundwater Surface Water Interfaces." Unpublished Thesis. Colorado State University. Available at https://dspace.library.colostate.edu/handle/10217/100537.

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Cap Design – NAPL

*ROD Requires: "Cap design will include organoclay, **other reactive material**, and/or low permeability material, as necessary,……."*

- Oleophilic bio barrier - new technology being developed for sheen control
- The oleophilic bio barrier is a reactive material and meets the *other reactive material* ROD design requirement for NAPL

Polymer geocomposite wicking hydrocarbons

Design review provided by Arcadis who later was the contractor for Kinder Morgan for construction

Chalfant, Marc William. 2015. Oleophilic "Bio Barriers (OBBs) for Control of Hydrocarbon Sheens at Groundwater-Surface Water Interfaces." Unpublished Thesis. Colorado State University. Available at https://dspace.library.colostate.edu/handle/10217/100537.

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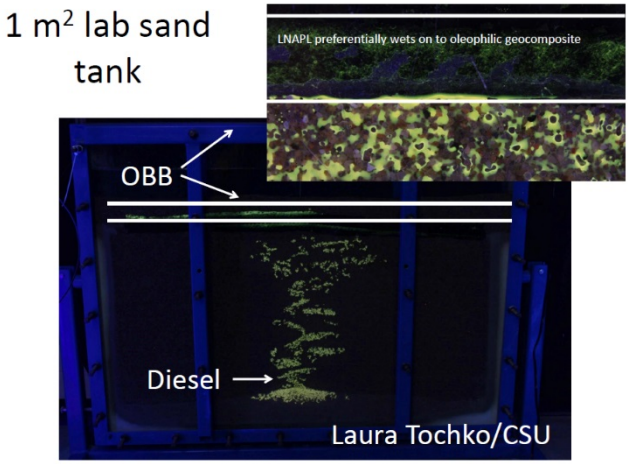
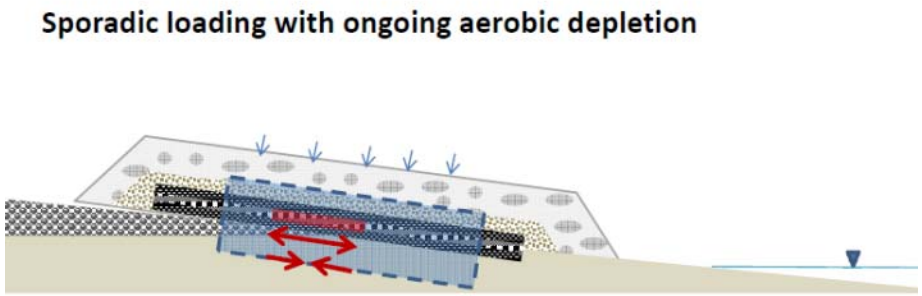
How does an OBB work



- LNAPL preferentially wets fabric of geocomposite

Photo courtesy of Colorado State University



- Sheen absorbed as river stage changes
- Surface water provides oxygen
- Captured NAPL degraded

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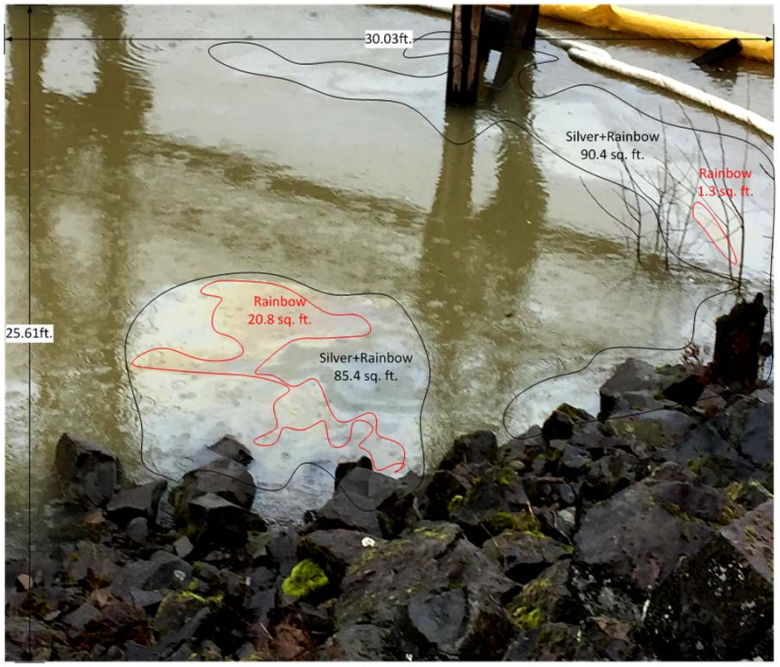
Oleophilic Bio Barrier Design



- Sheen area and intensity was measured
- Sheen volume 1 to 15 milliliters
- OBB capacity 3 liters/square meter
  - Capacity >5,000 sheen events without degradation
  - Years of absorption capacity to allow biodegradation

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Permitting - In-Water Work Constraints

- ROD requirements extended project into the nearshore areas
- In-Water Work Permit Required
  - In March 2017, notified that an ~180-day review time would be needed
- Adaptive solution, build what you can above the water in 2017!

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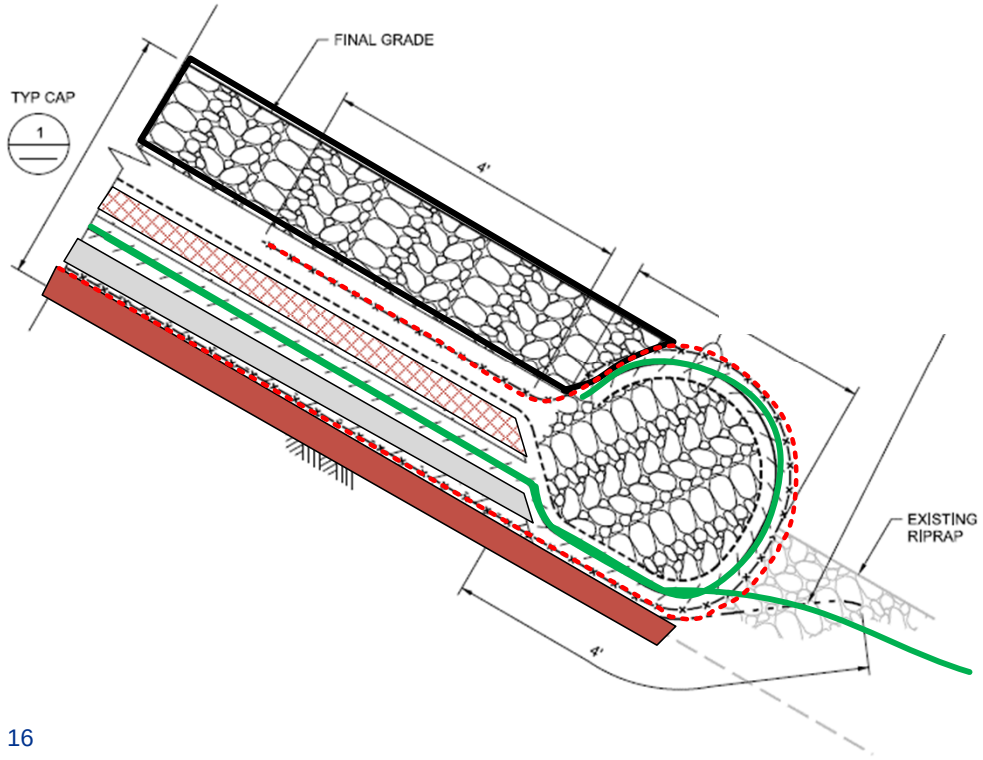
Cap Layers and Geotechnical Design



First leveling layer - Angular

Geogrid – Anchor trench

Second leveling layer – No clay

Oleophilic Bio Barrier - Horizontal

25% Carbon, 75% gravel layer

Armor Layer – 24 inch

For Phase 2 the Oleophilic Bio Barrier will be extended

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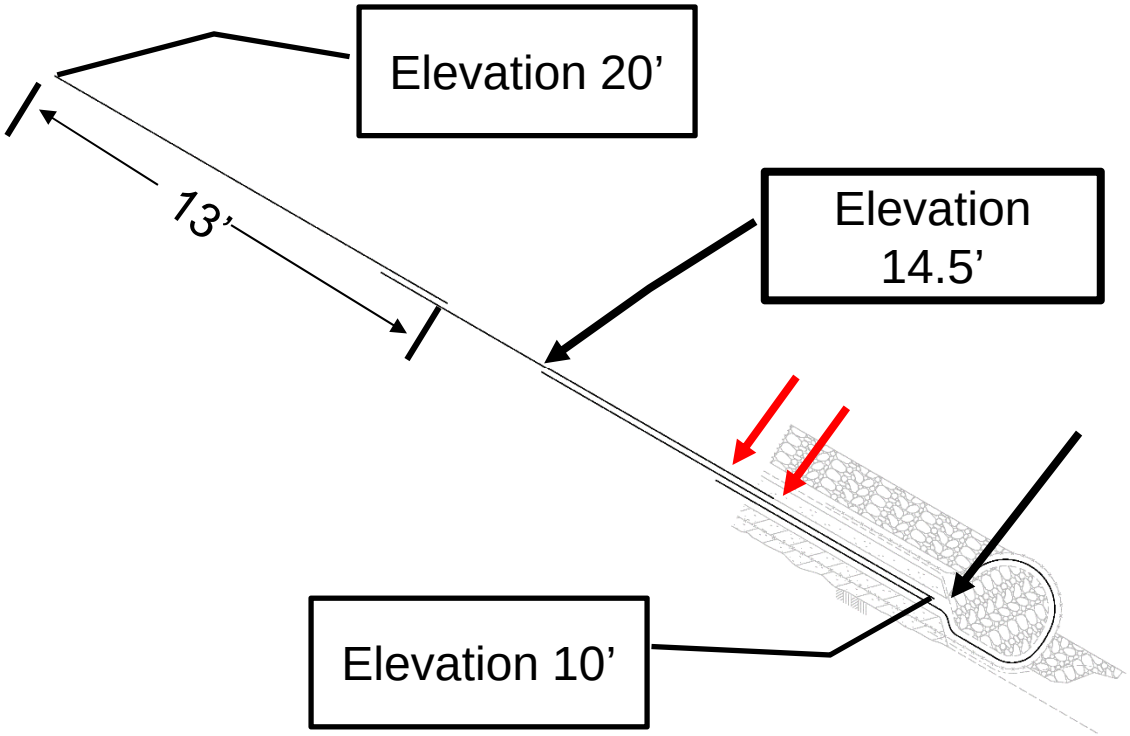
OBB Overlaps



- Four OBB panels were used to cover the slope from 20 to 10 foot elevation
- Panels are 13-feet wide
- Minimum two layers 10 to 14.5 foot elevation
- Maximum three layers 11 to 12 foot elevation

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Design and Construction

Remove existing rip rap.
Level slope with granular fill

Install geogrid in anchor trench

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Design and Construction

Grade geogrid level layer crowned in middle

Install Oleophilic Bio Barrier with overlaps

Place carbon – granular fill mixture

Place reused and new rip rap

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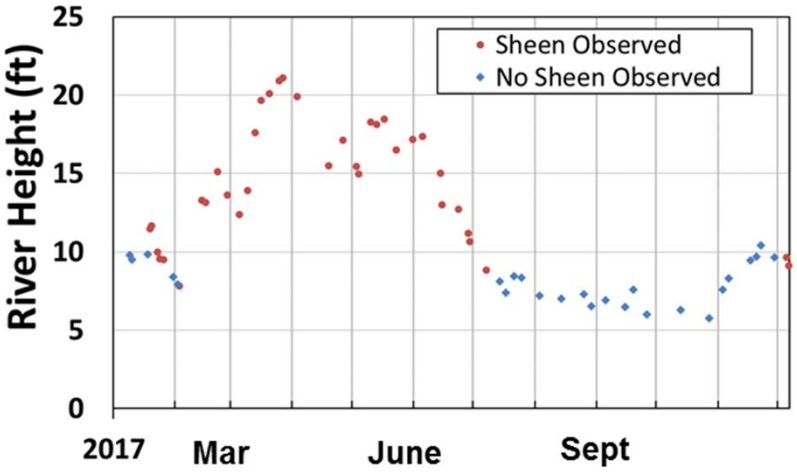
Before



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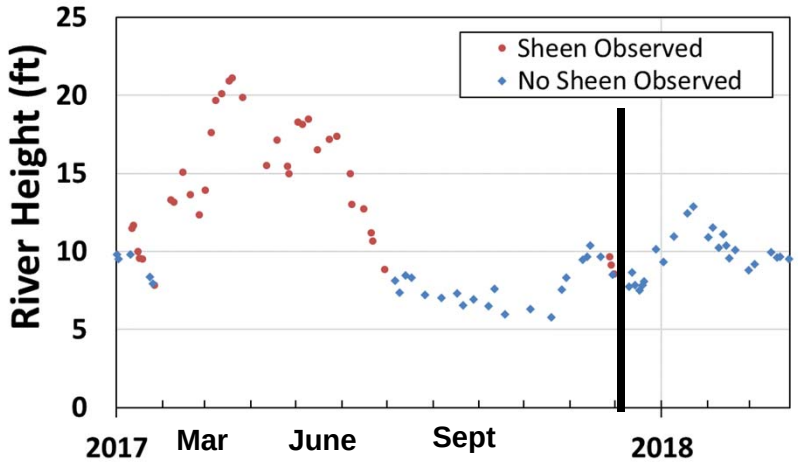
Before and After



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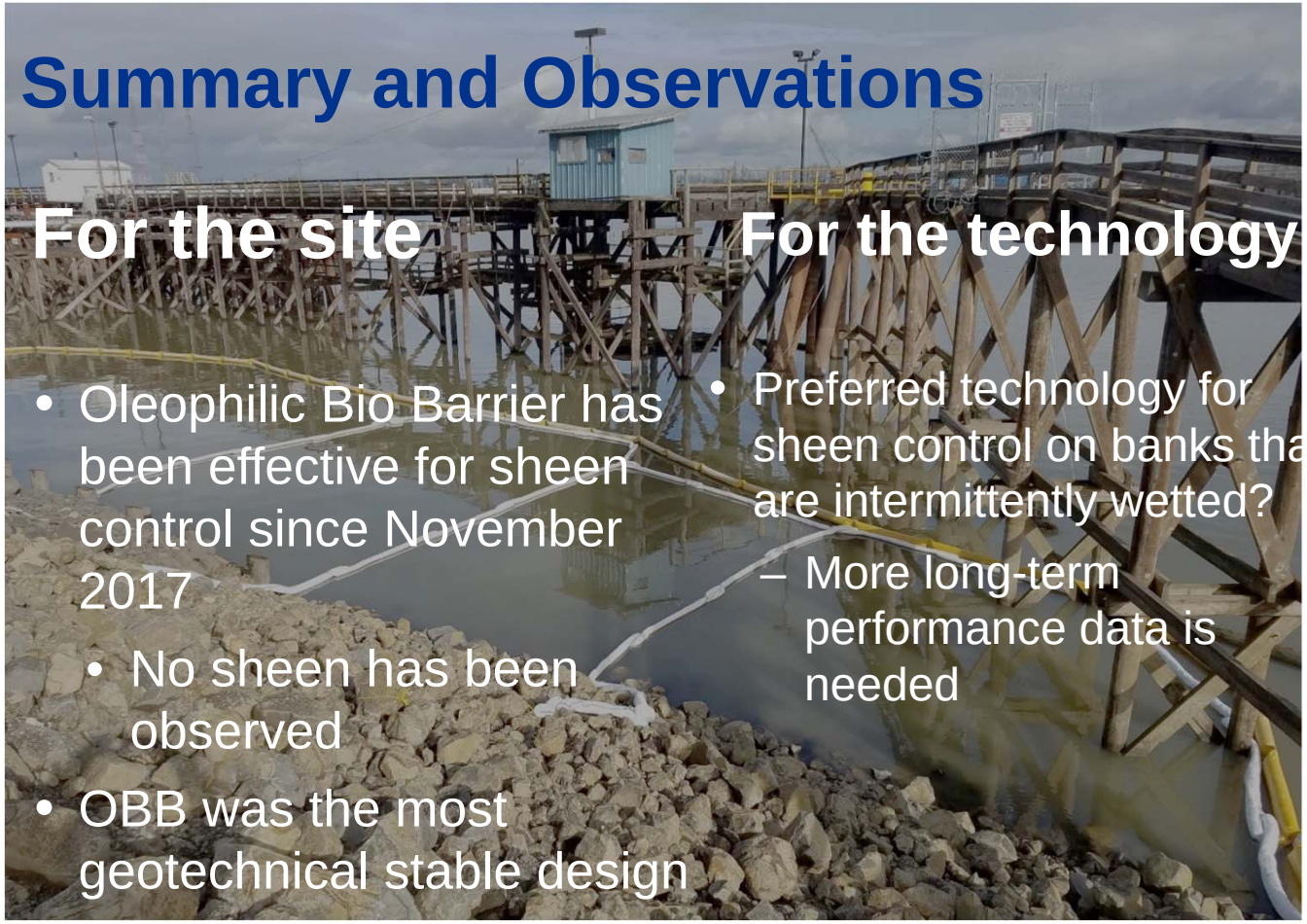
Summary and Observations



For the site

- Oleophilic Bio Barrier has been effective for sheen control since November 2017
  - No sheen has been observed
- OBB was the most geotechnical stable design

For the technology

- Preferred technology for sheen control on banks tha are intermittently wetted?
  - More long-term performance data is needed

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Thank you!

May 8, 2018

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